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PREDATION ON MEXICAN FREE-TAILED BATS BY BURROWING OWLS IN CALIFORNIA

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The Burrowing Owl (*Athene cunicularia*) is opportunistic in its feeding habits (Thomsen 1971, Zarn 1974, Snyder and Wiley 1976) and the abundance of items found in its pellets may be a reflection of relative prey availability (Glover 1953, Thomsen 1971, Gleason and Craig 1979). Among insect prey, Burrowing Owls primarily consume crickets, grasshoppers, ground beetles and dragonflies (Bent 1938, Glover 1953, Thomsen 1971). Small rodents such as meadow voles (*Microtus* spp.), deer mice (*Peromyscus* spp.), house mice (*Mus musculus*), pocket mice (*Perognathus* spp.), harvest mice (*Reithrodontomys* spp.), pocket gophers (*Thomomys* spp.) and kangaroo rats (*Dipodomys* spp.) are also typical food items (Earhart and Johnson 1970, Gleason and Craig 1979, Conroy and Chesemore 1987, Haug and Oliphant 1990). Burrowing Owls will also eat birds, including Horned Larks (*Eremophila alpestris*), Western Meadowlarks (*Sturnella neglecta*), Red-winged (*Agelaius phoeniceus*) or Brewer's Blackbirds (*Euphagus cyanocephalus*) and various shorebirds (Errington and Bennet 1935, Bent 1938, Thomsen 1971, Gleason and Craig 1979).

Occasionally, unexpected prey are found in Burrowing Owl pellets. Numerous remains of spadefoot toads (*Scaphiopus* spp.) were found in pellets in Kansas (Sperry 1941) and Nevada (Bond 1942). Crayfish (*Cambarus* spp.) were the most common food items in a Colorado study (Hamilton 1941) and attacks on large snakes have also been documented (Fisher 1893).

Despite the potential to feed on whatever prey are readily available, there have been few reports of Burrowing Owls feeding on bats. Conroy and Chesemore (1987) discovered the remains of at least 13 mammalian species, but no bats in 963 Burrowing Owl pellets collected in Fresno County, California. Thomsen (1971) discovered the remains of a single hoary bat (*Lasiurus cinereus*) in 2112 pellets collected from a colony of Burrowing Owls in Alameda County, California. Bent (1938), in a list of potential mammalian prey of Burrowing Owls, vaguely mentioned bats only as a possible prey source. Upon examination and analysis of Burrowing Owl pellets collected in April 1989, we found numerous bat skeletal remains. This study presents evidence of Burrowing Owl predation on Mexican free-tailed bats (*Tadarida brasiliensis*) in Bakersfield, California.

MATERIALS AND METHODS

A pair of Burrowing Owls were observed for 2 wk in April 1989. A total of 18 pellets was collected from the vicinity of the burrow and from perches used by the owls in an undeveloped urban field in Bakersfield, California. Vertebrate remains were identified to species using diagnostic bone fragments including maxillae, dentaries, pelvics, limbs and vertebrae. The number of individual prey items found in an individual pellet was based on the maximum number of single, paired or vertebral elements that can exist in a single individual. Insect remains were identified to order but not quantified. All vertebrate identifications were based on comparisons with skeletons in the collection housed in the Department of Biology, California State University, Bakersfield. Though the precise species of bat caught is likely insignificant, identification criteria are included to assist in future studies.

House mice were identified by their dentition and western toads (*Bufo boreas*) by the size and shape of their vertebrae. Teeth were commonly missing from bat dentaries. In such cases, we based identifications on skeletal characters. Three similar species of small bats inhabit this area of California: the Mexican free-tailed bat, Yuma myotis (*Myotis yumanensis*) and long-eared myotis (*M. evotis*) The remains of these three species of small bats can be distinguished by dentaries. The Mexican free-tailed bat possesses five post-canine teeth, whereas the Yuma myotis and the long-eared myotis possess six. In *Myotis,* the mental foramen is ventral to the canine and the coronoid process is low, rounded and only slightly elevated above the mandibular condyle, whereas in the Mexican free-tailed bat, the mental foramen is ventral to the first premolar and the coronoid is pointed, tapered and narrow, extending well above the condyle. The angular process of the Mexican free-tailed bat is blunt and rounded, whereas in *Myotis* it is sharply pointed and tapers caudally Additionally, the zygomatic arch of the Mexican free-tailed bat is much broader dorsoventrally than in *Myotis* The Mexican free-tail bat also bears a dorsoventrally oriented preorbital ridge that is lacking in *Myotis,* and its epipubic process is elongate and pointed rather than rounded and short as in *Myotis.*

RESULTS AND DISCUSSION

In the 18 Burrowing Owl pellets collected, the dominant vertebrate prey item was the Mexican free-tailed bat (Table 1). Remains of at least 28 vertebrates were found, of which 20 (71%) were bats. One pellet contained the remains of at least four bats, another pellet contained at least three. Other vertebrate prey consisted of western toads and house mice. Two of the pellets contained non-

Table 1. Vertebrate prey found in 18 pellets from a pair of Burrowing Owls in Bakersfield, California (April 1989), including minimum number of individuals and number of pellets in which they appeared.

Taxon	Minimum Number of Individuals	Number of Pellets
Mexican free-tailed bat	20	12
House mouse	3	3
Western toad	3	3
Unidentified rodents	2	2

diagnostic small rodent-sized bones, whereas insect material (primarily coleopteran and orthopteran) was found in almost all pellets.

Although this is the first study that documents consumption of bats by Burrowing Owls, other raptors including the Great Horned Owl (*Bubo virginianus*), Barn Owl (*Tyto alba*), Cooper's Hawk (*Accipiter cooperii*), Sharp-shinned hawk (*A. striatus*), Swainson's Hawk (*Buteo swainsoni*), Red-tailed Hawk (*B. jamaicensis*), Northern Harrier (*Circus cyaneus*), American Kestrel (*Falco sparverius*) and Peregrine Falcon (*F. peregrinus*) have been found to feed on bats (Twente 1954, Baker 1962, Byre 1990). Baker (1962) reported that Great Horned Owl pellets from Carlsbad Caverns National Park in New Mexico were composed almost entirely of Mexican free-tailed bat bones and fur. Barn Owls have been observed to prey upon Mexican free-tailed bats exiting caves in Oklahoma (Twente 1954). In northeastern Illinois, Peregrine Falcons intercepted individuals of three species of bats (silver-haired, *Lasionycteris noctivagans*; big brown, *Eptesicus fuscus*; and red, *Lasiurus borealis* bats) migrating across Lake Michigan during the early morning (Byre 1990).

Upon exiting their roosts, usually in great numbers, bats can be extremely vulnerable to nocturnal avian predators (Baker 1962). Congregations of some bat species have been observed in the evening around artificial lighting. In accordance with large aggregations of potential prey, Burrowing Owls in our study may have hunted near artificial light sources several hundred meters from their burrow. For example, in 1997 at a separate location, a Burrowing Owl was seen repeatedly attacking a bat flying around a lightpost in a shopping mall parking lot. At the time of our study, numerous businesses, residential buildings and other structures suitable for roosting were within a few hundred meters of the burrow. Although these sites were not searched for roosts in April 1989 when the pellets were collected, any such structures are potential havens for groups of bats (Hall and Kelson 1959, Walker 1975, Barclay et al. 1980, Kunz 1982, Jameson and Peeters 1988, Thomas and LaVal 1988). These sites were well within the limits of known home ranges ($\leq$3.43 km^2) of Burrowing Owls (Haug and Oliphant 1990), and could have provided an opportunity for predation close to the bats' roost(s).

Our results provide evidence that, for at least two weeks, the owls were opportunistic, nocturnal predators taking advantage of an accessible supply of bats. In other localities in Bakersfield, accumulations of western toad carcasses have been found associated with Burrowing Owl burrows, or pellets have been packed with insect parts (pers. obs.). Bat roosts were most likely in buildings close to the owls' burrow.

RESUMEN.—Un análisis de 18 egragópilas de *Athene cunicularia* reveló que la presa vertebrado dominante fue *Tadarida brasiliensis.* Las egragópilas fueron recolectadas durante un período de dos semanas en abril de 1989 en un área urbana de Bakersfield, California. Esta es la primera documentación de depredación de murcielagos por *Athena cunicularia.* Otros restos identificables de vertebrados en las egagrópilas incluyeron a *Bufo boreas* y *Mus musculus*

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NEAREST NEIGHBOR NEST DISTANCES, HOME RANGE AND TERRITORY AREA OF THE MADAGASCAR FISH-EAGLE (*HALIAEETUS VOCIFEROIDES*)

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The Madagascar Fish-Eagle *(Haliaeetus vociferoides)* is endemic to Madagascar and considered endangered due to its low and declining population of only 100–120 breeding pairs (Langrand and Meyburg 1989, Collar et al. 1994, Rabarisoa et al. 1997). Little was known about the species' biology or ecology until intensive studies began in 1991 aimed at understanding its natural history, with emphasis on those ecological parameters that may influence survival and to suggest a design for a conservation recovery program (Watson 1997).

The area needed to support a breeding pair of eagles is an important ecological parameter that can determine the carrying capacity of suitable habitat (Newton 1979), and can be estimated from measurement of nesting density, nearest neighbor nest distance, home range area or territory area. In continuous suitable habitat, noncolonial nesting raptors generally space themselves by maintaining a mutually exclusive territory which pairs defend by a variety of behavioral displays and interactions (Newton 1979). Nearest neighbor distances can be used to estimate nest spacing in species that nest only along linear ecotones, such as the Madagascar Fish-Eagle which nests only along woodland to water ecotones. An estimate of pair spacing can be used to extrapolate population carrying capacity if the area of suitable habitat is known, carrying capacity being an important estimate for setting a target population size for endangered species recovery. In this report, we evaluate the relative suitability of nearest neighbor nest distance, home range and territory size as indices of the area needed to support a pair of eagles and their use in estimating the Madagascar Fish-Eagle population carrying capacity.